Microgrids and EU law

Behrendt, Jamie

Published in:
Energy Policy

DOI:
10.1016/j.enpol.2023.113483

Energy Policy 177 (2023) 113483

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Microgrids and EU law: Three Microgrid models to solve one regulatory puzzle

Jamie Behrendt

Groningen Centre of Energy Law and Sustainability, University of Groningen, the Netherlands

ARTICLE INFO

Keywords:
Energy transition
Microgrids
Energy law
Legal uncertainty

ABSTRACT

Microgrids are decentralised electricity systems that can operate independently of the main electricity network, and which have the potential to contribute to the energy transition towards a more sustainable energy mix. However, the integration of the system in the EU electricity market is not regulated and the resulting uncertainty discourages the system's development. This article provides the first step towards increased legal certainty for microgrid users and initiators by developing a regulatory approach based on three different microgrid ownership and operation models. If the existing rules in EU energy law allow for some flexibility to include electricity household consumers under the provisions of Closed Distribution Systems and allow for Citizens Energy Communities to manage part of the distribution system, the legal framework does offer possibilities to regulate microgrids. Nevertheless, many legal questions remain, in particular regarding responsibilities of active customers, consumption management, and regulation of flexibility services. In addition, the regulatory approach towards microgrids depends on EU Member States granting energy communities the right to manage part of the distribution network, which now depends on the discretion of the Member States. This discretionary nature should be reconsidered given the significant potential for local initiatives to contribute to the energy transition.

1. Introduction

In the European Union (EU), growing concerns regarding energy availability as well as the ageing infrastructure of the electricity transmission and distribution networks call for changes in the electricity market (Shabalov, 2021). Changes, both technical and legal, must address the climate change induced challenges for the electricity sector. These challenges include the reduction of greenhouse gas (GHG) emissions, safeguarding security of electricity supply, and ensuring the competitiveness of the electricity market (L'Abbate, 2008). Increasingly integrating distributed energy resources (DER) in the centralised electricity grid can contribute to achieving this.

DER are local energy generation technologies which produce, store and manage energy, oftentimes from renewable sources (RES) by integrating solar panels, small wind farms and battery storage systems (Noonan and Fitzpatrick, 2020). As will be elaborated in the following section, the centralised grid has difficulties integrating DER. This shifts the attention to smaller scale, decentralised electricity systems, such as microgrids, which can facilitate the integration of DER whilst also creating local energy resiliency to ensure secure electricity supply (Warneryd et al., 2020).

In the EU, various Member States (MS) have implemented microgrids to test the system, such as the Netherlands, Germany, and Greece.[1] However, EU law lacks a clear legal definition and regulation of microgrids. This is problematic, as the resulting legal uncertainty limits microgrids in unfolding their full potential (Kojonsaari and Palm, 2021; Soshinskaya et al., 2014).[2] Microgrids thus require regulatory attention (Warneryd et al., 2020). In the academic literature, this has only been addressed to a very limited extent. Moreover, in earlier work, the integration of microgrids in EU energy law has been analysed by looking at the microgrid as a unified phenomenon. This means that no distinction has been made between various types of microgrids or their technical or ownership and operation structure (Mauger and Roggenkamp, 2021). This the hinders integration of the system in the current EU legal framework.

Considering that each microgrid is tailor-made to a specific location,

E-mail address: j.behrendt@rug.nl.

[1] For instance, the Schoonschip Community in the Netherlands, the Microgrid in Mannheim-Wallstadt, and the Kythnos Microgrid in Greece.

[2] This can be confirmed when looking at the development of the Sege Park in Sweden. The only non-solvable barrier encountered in the process of planning a microgrid were regulatory issues. This discourages potential stakeholders and customers to develop a microgrid. In the end, no microgrid was built at Sege Park due to legal barriers, in particular due to the involvement of the DSO.

https://doi.org/10.1016/j.enpol.2023.113483
Received 17 August 2022; Received in revised form 5 December 2022; Accepted 5 February 2023
Available online 7 April 2023

no microgrid is the same from a technical perspective (Wouters, 2015). However, as will be demonstrated in this article, similarities between microgrids, but also between microgrids and other decentralised energy systems, can be observed when focusing on the ownership and operation structure of microgrids. These structures are categorised in literature as three different microgrid business models with differing ownership and operation structures: the DSO Monopoly Model (DSOMM), the Prosumer Consortium (PC), and the Free Market Model (FMM) (Schwaergerl, Tao, 2014). Regulating the microgrid models under the rules applicable to different decentralised energy systems that resemble those models can be used as a starting point for legally integrating microgrids in the electricity market. As a result, this paper presents a diversified approach to the regulation of microgrids, focusing on the regulatory puzzle of integrating the microgrid models in the EU legal framework, as opposed to the technical concept of microgrids.

The central question of this paper is: To what extent does the existing EU legal framework of the energy sector allow for the implementation of the different ownership and operation models of microgrids, such as the DSO Monopoly Model, the Prosumer Consortium, and the Free Market Model?

This question will be answered in the following sections by providing a doctrinal analysis of the existing legal framework in the EU that impacts the development of microgrids. Section 2 discusses the organisation of the EU electricity market and the benefits of microgrids within this market. Section 3 elaborates on the technical understanding of the concept of microgrids. In section 4, the need for regulating microgrids is addressed. Section 5 gives an overview of the different microgrid models, which are key for the legal analysis in the subsequent section. Section 6 addresses to what extent the existing EU legal framework of the energy sector allows for the implementation of the DSOMM, PC, and FMM microgrid models. Section 7 concludes that the legal framework for the EU energy market does offer possibilities to regulate microgrids, which provides the first step towards increased legal certainty for microgrid users and developers.

2. The potential of microgrids in the EU electricity market

The top-down centralised electricity grid in the EU is managed by a transmission system operator (TSO) and distribution system operator (DSO). Following the production of electricity, the TSO manages the high voltage network, whereas the DSO manages the lower voltage network to which household customers are connected. With market liberalisation of the electricity sector, the system became unbundled. This means that both the TSOs and DSOs are merely managing the grid, whereas commercial activities, such as producing or selling electricity, are carried out by third parties (Pollitt, 2007).

This electricity grid is not fully equipped to incorporate the necessary technical changes required to ensure energy availability and to reduce GHGs, as it 'inherently lacks the scalability and flexibility to coordinate DER with limited communication resources' (Lei Yan et al., 2022). Higher penetration of DER increases the volatility of electricity flows in local grids. When more electricity demand is being satisfied by intermittent energy sources on the local level, local supply may exceed local demand. This can lead to a reversed, bottom-up, electricity flow from the distribution system into higher network voltage layers. Consequently, uncertainty regarding electricity flows increases and DSOs face higher costs for developing, maintaining, and balancing their networks (Ruester et al, 2014).

Microgrids, however, have the potential to facilitate the integration of DERs in the electricity market (Warneryd et al., 2020). A microgrid is a decentralised grid which can disconnect from the main electricity grid and structure into 'local sub-grids that manage their power and energy balancing' (Pinto et al., 2021). The three main benefits of microgrids relate to (1) energy security, (2) economic benefits, and (3) integration of RES (Hirsch et al., 2018). Firstly, energy security can be increased due to the microgrid system's ability to island itself from the main electricity network. Islanding means that the system can function independently of the main electricity network (Pinto et al., 2021). Secondly, economic benefits refer to infrastructure cost savings,[3] fuel savings, and ancillary services that can be offered by the microgrid. Those services typically include frequency control support, voltage control support, congestion management, and black start services (Hirsch et al., 2018). Thirdly, microgrids can help to reduce GHG by increasing the share of RES in the electricity sector on a local level. Whether the potential of microgrid can be realised depends, amongst other things, on the regulatory support the system receives.

3. Microgrids from a technical perspective

Before addressing the regulation of microgrids, the technical characteristics of the system will be outlined to provide an overview of what is referred to as a microgrid. Microgrids are decentralised electricity systems, which means that they can operate independently of the main electricity network. Carpintero-Rentería et al. mapped the multitude of technical definitions attributed to microgrids and concluded that 'all share: (a) islanded and grid-connected functionalities; (b) clearly defined electrical boundaries, and (c) a control entity able to manage the energy resources along the loads.' (Carpintero-Rentería, 2019). Of these characteristics that microgrids share, that of islanding is what distinguishes it from other decentralised energy systems (Hirsch et al., 2018). In EU energy law, island operation is defined as: '[…] the independent operation of a whole network or part of a network that is isolated after being disconnected from the interconnected system […]' (Commission Regulation (EU) 2016/631)).

Islanding allows the microgrid participants to ensure security of electricity supply during a malfunction of the centralised grid, but it also enables them to offer ancillary services to system operators of the centralised grid (mainly the connecting DSO, but also TSO) (Mauger and Roggenkamp, 2021). Ancillary services include, but are not limited to, 'reactive power and voltage control, frequency responses and supply reserves, and regulation and load following' (Lopes et al., 2013). To offer those services, microgrids need to be equipped with smart grid technologies, which allow a two-way flow of both data and electricity between the microgrid and the main electricity network, but which also facilitate the management of the microgrid itself (I-scoop, 2022).

Within a microgrid, electric loads, small electricity generation systems as well as storage facilities to store produced energy sources are in proximity to each other (Lopes et al., 2013). The electricity generation technologies found in microgrids may range from: wind power systems, solar photovoltaic (PV) systems, hydropower systems, geothermal energy, biogas, and ocean energy. The four sources most found in microgrids however, are: solar, wind, micro-hydro, and diesel (Mariam et al., 2016).

Although not always included in a microgrid, storage devices can ensure that the system will not run out of power, as energy can be saved for later use. This also allows system users to balance the energy demand with its generation. This is particularly useful if the microgrid (primarily) relies on RES, considering the intermittency of renewables. Storage systems implemented so far include batteries and fuel cells (chemical storage systems), superconducting magnetic energy storage (electrical systems), pumped hydro, flywheels as well as compressed energy storage (mechanical systems), and thermal storage in the form of super-heated oil or molten salts (Mariam et al., 2016). How this technical set-up is organised and managed depends on the ownership and operation model of the microgrid, which will be discussed in the following sections.

[3] For instance, it can be less costly to construct a microgrid, compared to extending the distribution lines to technically challenging areas, such as mountains or islands.

4. Legal uncertainty and the need for regulation

To what extent does the existing EU legal framework of the energy sector allow for the implementation of the different ownership and operation models of microgrids, such as the DSO Monopoly Model, the Prosumer Consortium, and the Free Market Model? This question is relevant, as the lack of regulation creates considerable legal uncertainty regarding the integration of microgrids in EU law and the system's use in the electricity market.

From a legal perspective, two recurring issues have hindered the development of microgrids: microgrid islanding and the integration of microgrids within the unbundled electricity market.[4] This paper, however, will not focus on the regulation of islanding, as Roggenkamp and Mauger already analysed in detail which legal changes are needed to facilitate voluntary microgrid islanding (Mauger and Roggenkamp, 2021).[5] On the condition that microgrid islanding will be allowed, following the work of Roggenkamp and Mauger, the focus will be on the regulatory puzzle on how microgrids can be placed within the unbundled energy market, as this is not sufficiently discussed in the academic literature (Attanasio, 2021).

To enable and protect competition in electricity production and supply activities, the electricity sector has been unbundled. This means that there is a separation between (a) the operation of the electricity grid and (b) competitive commercial activities, like producing and supplying electricity (Pollitt, 2007). The TSO and DSOs are classified as market facilitators who manage, maintain, and expand the grid so that it can be used for the transport of electricity. Competitive commercial activities that rely on the grid are carried out by third parties. Within a microgrid, it is not given that there is a separation of grid operation and commercial activities, meaning there can be a deviation from the common legal organisation of commercial and network activities. Electricity producers and consumers can be directly involved in the management of their electricity production and consumption, whilst also managing the microgrid (Trivedi et al., 2022).

There is no regulation specifically tailored to microgrids. Hence, it is unclear to which extent they fall under the current unbundling regime, in particular when the operator of the microgrid also (partly) owns the system. This creates legal uncertainty and discourages the development of microgrids (Kojonsaari and Palm, 2021). This uncertainty can be reduced if microgrids can be regulated under the rules applicable to existing decentralised electricity systems which resemble the microgrid, such as Closed Distribution Systems (CDSs) or Citizens Energy Communities (CECs) and Renewable Energy Communities (RECs). Those systems facilitate the decentralised production and consumption of electricity and are integrated in the EU's legal framework. Hence, law exists that can potentially govern the use of microgrids if existing laws are adapted to the use of microgrids.

However, regulating microgrids under existing legal provisions as a unified phenomenon, meaning without making a distinction between existing microgrids, is difficult: A CDS is defined in article 38 of the 2019 Electricity Directive as an electricity distribution system within geographically confined industrial, commercial, or shared service sites (Directive (EU) 2019/944)). Microgrids do resemble CDSs as both are smaller-scale electricity systems within confined boundaries, but the CDS does not include systems that supply households with electricity. This excludes the regulation of microgrids which also include household customers Directive (EU) 2019/944)). Microgrids also share characteristics with both CECs and RECs. Both energy communities produce and consume electricity within a defined territory with the purpose to grant environmental, economic or social community benefits on a non-commercial basis (Directive (EU) 2019/944; Council Directive (EU) 2018/2001)). However, not all microgrids can be considered a CEC or a REC, as for some actors the involvement in a microgrid constitutes a commercial activity, which deprives the community of its status as CECs or RECs. Furthermore, not all microgrids rely on RES only, which limits the possibility to rely on the provisions of RECs.

Each microgrid differs in its purpose, ownership structure, and technical set-up,[6] which makes it difficult to integrate microgrids in the EU legal framework under the rules for one specific decentralised energy system. Whilst some microgrids could qualify as either of the above-mentioned systems, others fall outside of the existing rules. This, however, does not mean that it is impossible to regulate microgrids, it merely indicates that a different approach to the integration of microgrids in the EU legal framework is necessary. One possible approach is to differentiate between existing microgrids by using the three microgrid models mentioned earlier, to which the analysis now turns.

5. The ownership and operation of microgrids

Depending on microgrid ownership, the system can be classified into three different microgrid ownership models: the DSO Monopoly Model (DSOMM), the Prosumer Consortium (PC), and the Free Market Model (FMM) Those three models are an academic creation, first used by Schwaegerl and Tao (Schwaergerl, Tao, 2014). These models are used to categorise existing microgrids based on their ownership and operation structure, as summarized in Table 1, and has been used by various researchers since (Sachs et al. (2019); Soshinskaya et al. (2014); Li et al. (2015); Kaung Si Thu et al. (2020)).

The first model is the DSOMM in which a centralised DSO active in the respective MS, or in a country outside of the EU,[7] also owns and operates the microgrid or appoints a specific, related, DSO for the grid. This DSO is the driving force behind the microgrid's implementation. DSOMMs are typically built at technically challenging parts of the distribution network (such as remote areas), where it is economically feasible to construct a microgrid (instead of, for instance, extending electricity lines to those areas) (Schwaergerl, Tao, 2014). This provides the DSO with the additional benefit that the microgrid can be used for flexibility services, a range of services that can help to balance the demand and supply of electricity in the electricity network (EntsoE, 2017).

The second model, the PC, is run by consumers who both consume and produce their own energy. This can either be a single consumer or a group of consumers. This means that the operator of the system is also part of the legal entity that forms the microgrid. The purpose for the development of such a microgrid can range from decreasing dependence on the centralised grid to minimising energy bills or, depending on the regulation, maximising revenue from feeding excess electricity into the central electricity network for remuneration (Schwaergerl, Tao, 2014).

The third model is the FMM. According to engineering literature, the operation and ownership of the FMM is managed by any of the stakeholders involved, which could be one of the DSOs of the central electricity grid, the municipality, the electricity supplier, or electricity consumers. In this model, the motivation to develop a microgrid differs per project and can vary from economic to environmental concerns

[4] See, for instance, the microgrid developed by Tauron in Poland: Koschalka (2022), 'Poland's first self-sufficient electricity microgrid launched at former coal mine' (NfP) <https://notesfrompoland.com/2022/03/14/polands-first-self-sufficient-electricity-microgrid-launched-at-former-coal-mine/> accessed 19 April 2022; and Sege Park in Sweden: Kojonsaari and Palm (2021), 'Distributed Energy Systems and Energy Communities Under Negotiation' Technology and Economics of Smart Grids and Sustainable Energy 1.

[5] In essence, Maugen and Roggenkamp propose that islanding should: (i) Not only be limited to post-black-out situations, and (ii) they call for the change of technical requirements for islanding so that microgrids can fall under the existing legal framework as well.

[6] Considering that each microgrid is tailor-made to a specific location, to the needs of the stakeholders, and to the aim behind the system's construction.

[7] The terminology here is specified to the EU, but the models can also be applied outside of the EU.

Table 1
Microgrid ownership and operation models.

MG Model	Owner and Operator	Motivation	Primary Location in the EU	Primary Financial Stakeholders
DSO Monopoly Model	Centralised DSO or operator appointed by centralised DSO	Economic, Technical	Rural	Centralised DSO
Prosumer Consortium	Prosumer, MG specific DSO	Economic, Environmental, Independence	Urban, Rural	Prosumers
Free Market Model	Centralised DSO, Microgrid specific DSO	Economic, Environmental, Independence	Urban, Rural	Centralised DSO/MG specific DSO, Municipality, Supplier, Consumers
Technology Test Microgrids	Centralised DSO, MG specific DSO, Research Institution	Test technologies for microgrids	Urban, Rural, Lab	Research Institution

Source: This table summarises and builds upon the work of Schwaegerl and Tao as well as the analysis of existing microgrids in the EU by the author of this article.

(Schwaergerl, Tao, 2014). For the purpose of our research, no FMM has been identified in the EU yet. For this, three potential explanations exist. The first possible explanation is that the term 'free market' in FMM is misleading; the system could rather be described as a hybrid system between the DSOMM and the PC in which parties have a choice of which actors to involve. In that case, the FFM should be characterized as a Multi-Party Model (MPP). The second possible explanation is that the model, which has its origins in engineering literature, is not legally operational in the EU electricity market, as a party cannot simply take over the operation of the electricity grid. The third possibility is that the system is used as a category for microgrids which do not fall under the previous two models. If that is the case, it remains to be seen whether microgrids exist that are neither initiated by the DSO or a (group of) prosumer(s).

When examining existing microgrids in the EU, the DSOMM and the PC can be used to distinguish between various systems. For instance, Tauron, a DSO in Poland, has developed and now operates a microgrid at the site of a former coal mine (Koschalka, 2022).

This microgrid can be classified as a DSOMM. The microgrid provides electricity to 54 connected households by relying on solar and wind generators as well as gas. The system, however, cannot island itself as 'Poland's grid code currently prohibits working in island mode whilst using the distribution network operator infrastructure, but Tauron 'hopes to develop rules of cooperation to allow off-grid functioning to be permitted' (Koschalka, 2022). Another example of a more developed DSOMM is a microgrid in Mannheim Wallstadt, Germany, which dates back to 2006. Here, the DSO MVV Energie aimed to combine DER and controllable loads within a system that can shift from grid connected mode with the Mannheim electricity grid, to islanded mode (Khattabi et al., 2009). In the residential area in which the grid is situated, the centralised distribution grid was modified for the purposes of the More Microgrids Project. The system includes a 4.7 kW fuel cell, a 3.8 kW solar Photovoltaic (PV) system, a 1.2 kW flywheel storage unit, as well as two Combined Heat and Power Units rated at 9 and 5.5 kw (U.S Department of Energy, 2019).

An example of a PC is the Schoonschip Community in the Netherlands. This microgrid is owned and operated by the community members, who are independent of the main electricity network in the Netherlands (Schoonship Stichting). The community consists of 46 households living completely off-grid on various houseboats. The community utilises heat pumps that rely on the warmth of the river the boats are located on, and electricity is generated from solar PV panels. Each house is also equipped with a battery storage system. The 46 households are connected to an intelligent energy management system that coordinates the supply and demand of energy in the microgrid. This system also enables the community members to trade energy between each other, as they are all connected to one smart system. The microgrid mainly operates in islanded mode as it can fully cover its energy demand. In the Netherlands, the Community is unique from a legal perspective as the community obtained a special permit that grants full ownership of microgrid (Metabolic, 2019). This means that the Schoonschip community has its own local distribution grid.

In addition, building upon the work of Schwaegerl and Tao, several existing microgrids do not fit into the existing categories, namely those developed as pilot projects to test technologies, hereinafter referred to as Technology Test Microgrids (TTM). Those microgrids are built either by research organisations or commercial parties to test and demonstrate applications that can potentially be used in microgrids (EntsoE, 2022) Only after those systems are used and operated by either a centralised DSO, a microgrid specific DSO or the Prosumers would they fit into the existing categorisation.

These microgrid models will be used in this paper, as this classification provides criteria to distinguish between different microgrids and allows this research to build upon the existing academic discourse on microgrids by focusing on the regulation of the microgrid models.

6. Regulating microgrids based on different ownership models

This section will assess to what extent the different microgrid models can be integrated into EU energy law. The DSOMM and the PC will be analysed in detail, whereas the FMM will only be addressed to a limited extent as this model is not represented in the EU. The legal analysis will exclude the TTM, considering that this only refers to test microgrid technologies, which is not relevant to the integration of microgrids in the EU energy market.

The legal framework considered in this section are the rules applicable to a CDS or those applicable to a CEC. These provisions are acknowledged to be the 'existing EU legal provisions that could serve to set up microgrids with as much legal certainty as possible' (Mauger and Roggenkamp, 2021). RECs will be excluded, as not all microgrids depend on renewable energy only and thus the scope of CECs is wider.

The legal characteristics of both the CDS and the CEC are outlined in Table 2. The CDS regulates the grid use and the role of a system operator, whereas CECs regulate the activities of certain system users that generate and store energy within a community. This offers two different perspectives on how microgrids and their users could be regulated, depending on the involvement of the microgrid users. The DSOMM is run by the DSO who also operates a part of the larger distribution network. If that DSO operates the microgrid, no active participation of the electricity consumers in the microgrid is needed in the operation of the system. Hence, to regulate the DSOMM, the focus should lie on regulating the grid and on the role of the operator managing the system instead of the system users. The operation of the PC, on the other hand, does require the active participation of the microgrid's consumers, as apart from owning the resources for generating electricity, they either operate the grid themselves, or actively appoint a specific operator for those tasks. This means that not only the system, but also the system users must be regulated. Hence, in the following section, it will be argued that the DSOMM can be regulated under the rules applicable to a CDS, that the PC can be regulated as a CEC, and the FMM can be regulated either as a CDS or a CEC, depending on the ownership of the microgrid (see Table 3).

Table 2
Closed Distribution Systems vs. Citizen Energy Communities.

Directive, 2019/944	Article 38 Closed distribution systems	Article 16 Citizen energy communities
Definition	A system which distributes electricity within a geographically confined industrial, commercial, or shared service site and does not […] supply household customers, may be considered as a closed distribution system if: (a) for specific technical or safety reasons, the operations or the production process of the users of that system are integrated; or (b) that system distributes electricity primarily to the owner or operator of the system or their related undertakings.	a legal entity that: (a) is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises; (b) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; and (c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders.
Owner	Legal Person	Legal entity effectively controlled by members or shareholders
Purpose	To distribute electricity in areas not connected to the centralised grid for technical or safety reasons, or to distribute distributes electricity primarily to the owner or operator of the system or their related undertakings.	To provide environmental, economic or social community benefits to its members or shareholders
Primary Location	Rural areas, industrial sites	Urban or Rural
Primary Financial Stakeholders	DSO	Community Members

Table 3
The DSOMM as a CDS.

Microgrid Model	Closed Distribution System, Article 38 Directive, 2019/944
DSO Monopoly Model	✓ Yes, → If electricity household consumers can be connected to the CDS → If voluntary islanding is allowed

6.1. The DSO Monopoly Model as a form of closed distribution system

This section will argue that a DSOMM can be regulated under the rules applicable to a CDS. As defined in Table 2, CDS is a system which distributes electricity within a geographically confined industrial, commercial, or shared service site. In such a system, the operation, or the production process of the users of that system are either integrated for specific technical or safety reasons; or electricity is distributed primarily to the owner or operator of the system or their related undertakings (Directive (EU) 2019/944, art 38)). Existing CDSs include, for instance, hospitals, campuses, or airports.

The definition of the CDS aligns with the description of campus microgrids, which include the same sites as existing CDSs. Those microgrids are oftentimes managed by the local DSO, as economic or technical reasons make it more feasible to resort to a microgrid instead of extending the centralised electricity network to those sites. The difference between a microgrid and a CDS is that the microgrid can island itself from the centralised grid. It is argued that the DSOMM should be considered under the provisions governing a CDS.

If a DSOMM wants to be considered a CDS, the operator of the system must apply for a license under the application procedure laid down by individual MS (ECRB, 2018). Once the license has been obtained, the CDS/DSOMM can request a connection to either the transmission or distribution system of the central electricity grid to provide the services discussed in the previous section, as outlined in the Commission Regulation on Demand Connection (Commission Regulation (EU) 2016/1388)). Regulating the DSOMM as a CDS would qualify the microgrid as a distribution system. This implies that the system operator of the microgrid needs to comply with the unbundling rules applicable to DSOs. The DSO would not be allowed to produce and sell electricity within a microgrid but should merely manage the grid. However, the operator of the microgrid could rely on the exemption under the '100, 000 customers rule', according to which DSOs serving less than 100,000 customers are exempt from legal and functional unbundling (Directive (EU) 2019/944, art 35 para 4)). Without this exemption, a DSO would not be allowed to manage the microgrid itself, necessitating a separate operator and associated increased costs. However, based on the exemption, the DSOMM can become 'a truly integrated entity that owns and operates production, distribution and supply simultaneously' (Mauger and Roggenkamp, 2021). Furthermore, classifying the DSOMM as a CDS would entail that MS can provide for National Regulatory Authorities (NRA) to *exempt* the operator of the CDS from the requirements: (i) to procure flexibility services and to submit network development plans to the NRA (ii) not to own, develop, manage or operate recharging points for electric vehicles; and (iii) not to own, develop, manage or operate energy storage facilities (Directive (EU) 2019/944 art 38 para 2)).

Considering the definition of a CDS, the CDS offers a viable regulatory framework for campus microgrids run by the DSO, as campus microgrids usually do not supply households with electricity. As the legal definition of a CDS explicitly excludes systems that provide electricity to household customers, legal issues only arise if the DSOMM also supplies electricity to household customers. In a CDS, merely incidental use of the system by households is permitted (Directive (EU) 2019/944, art 38 para 2)). As the connection to a microgrid is not incidental, this creates a legal problem as a DSOMM that is also connected to households cannot classify as a CDS. There is, however, a solution. With the emergence of CECs, which will be elaborated on in the following section, the 2019 Electricity Directive 'empowers Member States to allow citizen energy communities to become distribution system operators either under the general regime or as 'closed distribution system operators'' (Directive (EU) 2019/944consideration 47)).

Hence, if household customers in a CEC may classify their system as CDS, it follows that a DSOMM can classify as a CDS even if it includes household customers. Consequently, the system operator in the DSOMM would be subject to the same rules as a regular DSO, whilst being allowed to supply households with electricity.

6.2. The Prosumer Consortium as a form of Citizens energy community

Not all microgrids can classify as a CDS, considering the defined purpose of a CDS, as seen in Table 2. This affects the PC, which is run by consumers who both consume and produce their own energy. As mentioned earlier, the purpose of such a PC can range from decreasing dependence on the centralised grid structure to minimising energy bills or, depending on the regulation, maximising revenue from feeding excess electricity into the central electricity network for remuneration (Schwaegerl, Tao, 2014). This is not reflected in the definition of the CDS (Directive (EU) 2019/944, art 38)). Instead, the PC does resemble the CEC, which is a community that organises collective energy actions to provide environmental, economic or social community benefits to its members or shareholders (Directive (EU) 2019/944, art 16)). The community, just like a PC, can take various legal forms, for instance, that of an association, a cooperative, a partnership, a non-profit organisation or a small/medium-size enterprise (European Commission, 2022). The difference between a PC and a CEC is that the former can island itself, and thus has more defined boundaries, while CECs can also take shape virtually (SmartEn, 2022).

Legally, CECs are regulated under the 2019 Electricity Directive, which includes rules that enable active consumer participation in markets, either by generating, consuming, sharing or selling electricity, or by providing flexibility services through demand-response and storage (Directive (EU) 2019/944, art 16)). Furthermore, MS may grant CECs the possibility to manage part of the distribution networks in their area of operation, and grant CECs the status of a distribution system operator, either under the legal regime of a regular DSO or a CDS (as explained in the previous section) (Directive (EU) 2019/944, art 16)). This means that even if the microgrid is classified as a CEC, it needs to assign an operator. This operator will have to comply with the same rules as the operator of the CDS or the regular DSO. If the PC is seen as a form of CEC, these provisions can serve as a legal basis for allowing a PC to manage part of the distribution system and become independent of the DSO of the centralised grid. Hence, the PC also needs to comply with the same licensing regime and the unbundling rules discussed in the previous section applicable to the CDS.

The Directive makes clear that the rights and obligations of stakeholders in a community should be in accordance with the roles each party undertakes, i.e., the roles of final customers, producers, suppliers, or distribution system operators (Directive (EU) 2019/944, consideration 46)). This means that microgrid users in a PC might simultaneously be subject to the rules applicable to a system operator as well as those applicable to a producer or consumer. However, if electricity consumers both produce and consume their electricity or store electricity generated within their premises in confined boundaries, those parties classify as active customers and can delegate certain responsibilities to third parties. Per article 15 para 2(d), they may 'delegate to a third party the management of the installations required for their activities, including installation, operation, data handling and maintenance, without that third party being an active customer' (Directive (EU) 2019/944, art 2)). The delegated party could be regarded as the operator of the system and the customers in the CEC can take up the role of producer and consumer, which will be managed under the legal provisions of active customers.

Considering microgrid consumers as active customers who are allowed to manage their distribution system provides the first step to integrating microgrid users into the legal framework. However, the risks of combining the roles of consumer and investor in an electricity system must be considered.

As pointed out by Long et al. the different participants in the development and operation of a microgrid have different interests, and 'if the incentive mechanism does not balance the interests of all parties, it will seriously affect the quality and efficiency of micro-grid project development' (Long et al., 2019). This can be illustrated by the following example: The right to switch suppliers is a right granted to energy consumers, but it constitutes a risk for investors (Directive (EU) 2019/944, art 12)). For example, in the Schoonschip community in Amsterdam, electricity is produced by 46 houseboats that are connected to their microgrid (Schoonship Stichting). Suppose that five members (a number taken at random for this example) of the community would decide to leave, this could not only trigger a power shortage for the remaining parties but would also increase the costs for running the system as additional power needs to be purchased or stored. Consequently, the remaining community members might find themselves in a financial situation that is no longer viable.

To adequately protect all microgrid users and the systems developers, the incentives of all parties must be considered and 'each stage of micro-grid project development requires corresponding mechanisms to motivate all parties to participate in the project development of micro-grids, actively and efficiently' (Long, 2019). Hence, the contractual obligations must therefore be clearly defined in advance, balancing the different parties' interests, so that no member of the community is negatively influenced by actions of other parties, such as an exit from the microgrid. This does not mean that a microgrid user should lose the right to switch suppliers, but it should be contractually determined which microgrid user can make use of this (and other) rights, and which obligations come with joining a microgrid, which is a matter of contract law for which the microgrid users are responsible.

6.3. *The Free Market Model*

So far, it has been demonstrated that when interpreting the provisions concerning the CDS, energy communities and active customers, the 2019 Electricity Directive can facilitate the regulation of the DSOMM and the PC. However, the regulation of the FMM proves to be more difficult, as the motivation behind the system's construction and the financial stakeholders involved are dependent on the ownership of the microgrid. In the FMM, ownership can be taken over by either the DSOs of the central electricity grid, the municipality, the electricity supplier, or electricity consumers (Schwaergerl, Tao, 2014).

As no FMM has been identified for this research, this section will only provide a brief overview of how the FMM could be regulated. Instead of identifying one regulatory approach for the FMM, the system's regulatory framework should be assessed on a case-by-case basis, either regarding the system as a CDS or a CEC, depending on which actors are involved. If the DSO who manages part of the larger distribution network is involved in the microgrid, the DSO's activities qualify as the primary commercial activity, and thus cannot qualify as a CEC. In such a case, the FMM could be regulated as a CDS. If there is no involvement of the DSO, and the motivation to construct such a system exceeds the purposes indicated in the definition of the CDS, then the microgrid should be regulated under the rules applicable to CECs. This means that although in the academic literature the FMM is distinguished from the DSOMM and the PC, legally the system resembles either of the systems, depending on the actors involved (see Table 4).

When assessing whether a FMM should be regulated as a CDS or a CEC, the following chart in Table 5 can be used as guidance. The primary criterion depends on whether (or not) the centralised DSO is involved is involved in the operation of the microgrid, or whether (or not) microgrid users are considered active customers.

7. Conclusion and policy implications

The central question in this article is to what extent the existing EU legal framework for the energy sector allows for the implementation of three different microgrid models, abbreviated as DSOMM, PC and FMM. The basic answer to this question is that EU law can facilitate the regulation of these microgrid models if existing rules are adapted to include microgrids.

More specifically, EU law governs the operation of decentralised electricity systems that are similar to microgrids such as the CDS, CEC, with the exception that those existing systems do not island themselves. In essence, microgrids could be seen as a type of CDS or CEC, depending on the ownership structure of the microgrid as well as on the involvement of the DSO and the microgrid users.

Table 4
The PC as a CEC.

Microgrid Model	Citizens Energy Community, Article 16 Directive, 2019/944
Prosumer Consortium	✓ Yes, → If microgrid users are considered active customers. → If voluntary islanding is allowed

Table 5
Microgrid models within EU energy law.

Microgrid Model	Closed Distribution System Article 38 Directive, 2019/944	Citizens Energy Community Article 16 Directive, 2019/944
DSO Monopoly Model	✓ Yes, → If electricity household consumers can be connected → If voluntary islanding is allowed	× No, - No, because the involvement of the DSO constitutes a commercial activity.
Prosumer Consortium	× No, - No, because the PC is built for economic, environmental, or independence reasons, not for specific technical or safety reasons	✓ Yes, → If microgrid users are considered active customers. → If voluntary islanding is allowed
Free Market Model	✓ Yes, → If the centralised DSO is involved → If electricity household consumers can be connected → If voluntary islanding is allowed	✓ Yes, → If the centralised DSO is not involved → If microgrid users are considered active customers. → If voluntary islanding is allowed

The DSOMM could be regulated under the rules applicable to a CDS. This requires that electricity household consumers should also be included in the provisions of CDSs. In addition, the operator of the DSOMM should be able to invoke the exemption under the 100,000 customer rule.

The PC could be regulated under the rules applicable to a CEC. If the PC is regulated under the rules applicable to the CEC, the law must allow the community to manage part of the distribution system and the system needs to be allowed to island itself. The latter also applies to microgrids which are classified as DSOMM under the rules of the CDS.

The focus on microgrid ownership and operation models makes this article one of the few existing legal papers specifically addressing the regulation of microgrids. Nevertheless, many legal questions remain, in particular concerning the responsibilities of active customers, consumption management in a microgrid, and the regulation of flexibility services. Those questions cannot be answered by relying on the existing rules yet, which mainly focus on the operation of the electricity systems. In addition, from a regulatory point of view, those questions are not specific to microgrids, or the operation of a CDS or CEC, but generally apply to the development of flexible demand independently of microgrids. In addition, the regulatory approach depends on MS granting energy communities the right to manage part of the distribution network. This is not a right inherent to energy communities, but depends on the discretion of the MS. However, it should be reconsidered whether this right should remain discretionary considering the significant potential that local initiatives may have for the energy transition.

In sum, the legal framework for the EU energy market does provide possibilities to regulate microgrids, but the actual implementation of microgrids is dependent on the MS to develop such systems. How microgrids are implemented in specific MS exceeds the scope of this article and is a relevant topic for future research.

CRediT authorship contribution statement

Jamie Behrendt: Conceptualization, Formal analysis, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Acknowledgements

I wish to thank Edwin Woerdman, Hans Vedder and Lea Diestelmeier for their helpful comments and guidance when writing this article.

References

Attanasio, 2021. The regulation of microgrids. In: Roggenkamp, et al. (Eds.), Energy Law, Climate Change and the Environment (Elgar Encyclopaedia of Environmental Law).
Commission Regulation (EU) 2016/631 of 14 April 2016 Establishing a Network Code on Requirements for Grid Connection for Generators [2016] OJ L112.
Commission Regulation (EU) 2016/1388 of 17 August 2016 Establishing a Network Code on Demand Connection [2016] OJ L 223/10.
Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on Common Rules for the Internal Market for Electricity and Amending Directive 2012/27/EU [2019] OJ L 158/125.
Carpintero-Rentería, et al., 2019. Microgrids literature review though a layers structure. Energies 12.
ECRB, 2018. Regulatory Framework for Closed Distribution Systems in the Energy Community Contracting Parties Status Review. Energy Community Regulatory Board.
EntsoE, 2017. Distributed Flexibility and the Value of TSO/DSO Cooperation (Working Paper for fostering active customer participation).
EntsoE, 2022. Microgrid for Reliability of Supply. EntsoE. https://www.entsoe.eu/Technopedia/techsheets/microgrid-for-reliability-of-supply. (Accessed 2 June 2022).
European Commission, 2022. Energy Communities. EC. https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en. (Accessed 8 June 2022).
Hirsch, et al., 2018. Microgrids: a review of technologies, key drivers, and outstanding issues. Renew. Sustain. Energy Rev. 402.
I-scoop, 2022. Smart Grids: Electricity Networks and the Grid in Evolution. (*I-scoop*). https://www.i-scoop.eu/industry-4-0/smart-grids-electrical-grid/. (Accessed 4 May 2022).
Khattabi, et al., 2009. Advanced architectures and control concepts for MORE MICROGRIDS. More Microgrids DF5 3.
Kojonsaari, Palm, 2021. Distributed energy systems and energy communities under negotiation. Technology and Economics of Smart Grids and Sustainable Energy 1.
Koschalka, 2022. Poland's First Self-Sufficient Electricity Microgrid Launched at Former Coal Mine. NfP. https://notesfrompoland.com/2022/03/14/polands-first-self-sufficient-electricity-microgrid-launched-at-former-coal-mine/. (Accessed 19 April 2022).
Li, et al., 2015. Peer to peer smart energy distribution networks. D2.2 Regulatory, Business, Technological, and Social Enablers and Barriers of P2P Energy Transfer.
Long, et al., 2019. Incentive mechanism of micro-grid project development. Sustainability 163.
Lopes, et al., 2013. A view of microgrids. WIREs Energy Environ 86.
Mariam, et al., 2016. Microgrids: architecture, policy and future trends. Renew. Sustain. Energy Rev. 477.
Mauger, Roggenkamp, 2021. Smart Island energy systems. Deliverable D7.3 Developing Microgrids in the EU.
Metabolic, 2019. Dutch Floating Community Rises to the Challenge of Climate Change. Metabolic. https://www.metabolic.nl/news/dutch-floating-neighborhood-rises-to-the-challenge-of-climate-change/. (Accessed 1 April 2022).
Noonan, Fitzpatrick, 2020. Will distributed energy resources (DERs) change how we get our energy? EPRS, Global Trends Unit PE 651, 944.
Pinto, et al., 2021. Power sharing in Island microgrids. Front. Energy Res. 8.
Pollitt, 2007. Vertical unbundling in the EU electricity sector. Intereconomics 292.
Ruester, et al., 2014. From distribution networks to smart distribution systems: rethinking the regulation of European electricity DSOs. Util. Pol. 229.
Sachs, et al., 2019. Framing microgrid design from a business and information systems engineering perspective. Business & Information Systems Engineering 729.
L'Abbate, et al., 2008. Distributed Power Generation in Europe: technical Issues for Further Integration' in Ali, et al. (2017), 'Overview of Current Microgrid Policies, Incentives and Barriers in the European Union, United States and China. Sustainability 9.
Schoonship Stichting, 'Het Plan' (Schoonship Amsterdam) <https://schoonschipamsterdam.org/#het-plan> accessed 20 May 2022.
Schwaergerl, Tao, 2014. The microgrid concept. In: Hatziargyriou (Ed.), Microgrids: Architectures and Control. John Wiley & Sons.
Shabalov, et al., 2021. The influence of technological changes in energy efficiency on the infrastructure deterioration in the energy sector. Energy Rep. 2664.
Si Thu, Kaung, et al., 2020. Simulation of blockchain based power trading with solar power prediction in prosumer Consortium model. In: International Conference and Utility Exhibition on Energy, Environment and Climate Change (ICUE).
SmartEn, 2022. Energy communities to increase local system efficiency. Smart Energy Europe Report.
Soshinskaya, et al., 2014. Microgrids: experiences, barriers and success factors. Renew. Sustain. Energy Rev. 65.
Trivedi, et al., 2022. Community-based microgrids: literature review and pathways to decarbonise the local electricity network. Energies 15.

U.S Department of Energy, 2019. Mannheim-Wallstadt. Microgrids at Berkley Lab. https://building-microgrid.lbl.gov/mannheim-wallstadt. (Accessed 4 May 2022).
Warneryd, et al., 2020. Unpacking the complexity of community microgrids: a review of institutions' roles for development of microgrids. Renew. Sustain. Energy Rev. 121.
Wouters, 2015. Towards a regulatory framework for microgrids—the Singapore Experience. Sustain. Cities Soc. 22.
Yan, Lei, et al., 2022. Architecture, control, and Implementation of networked microgrids for future distribution system. J. Mod. Power Syst. Clean Energy 286.